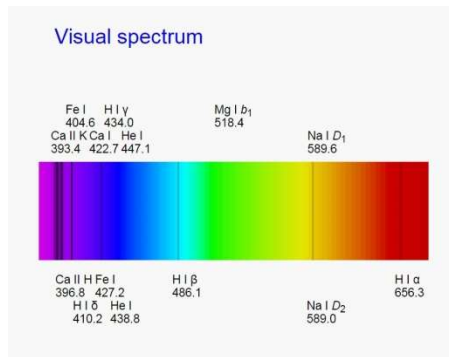


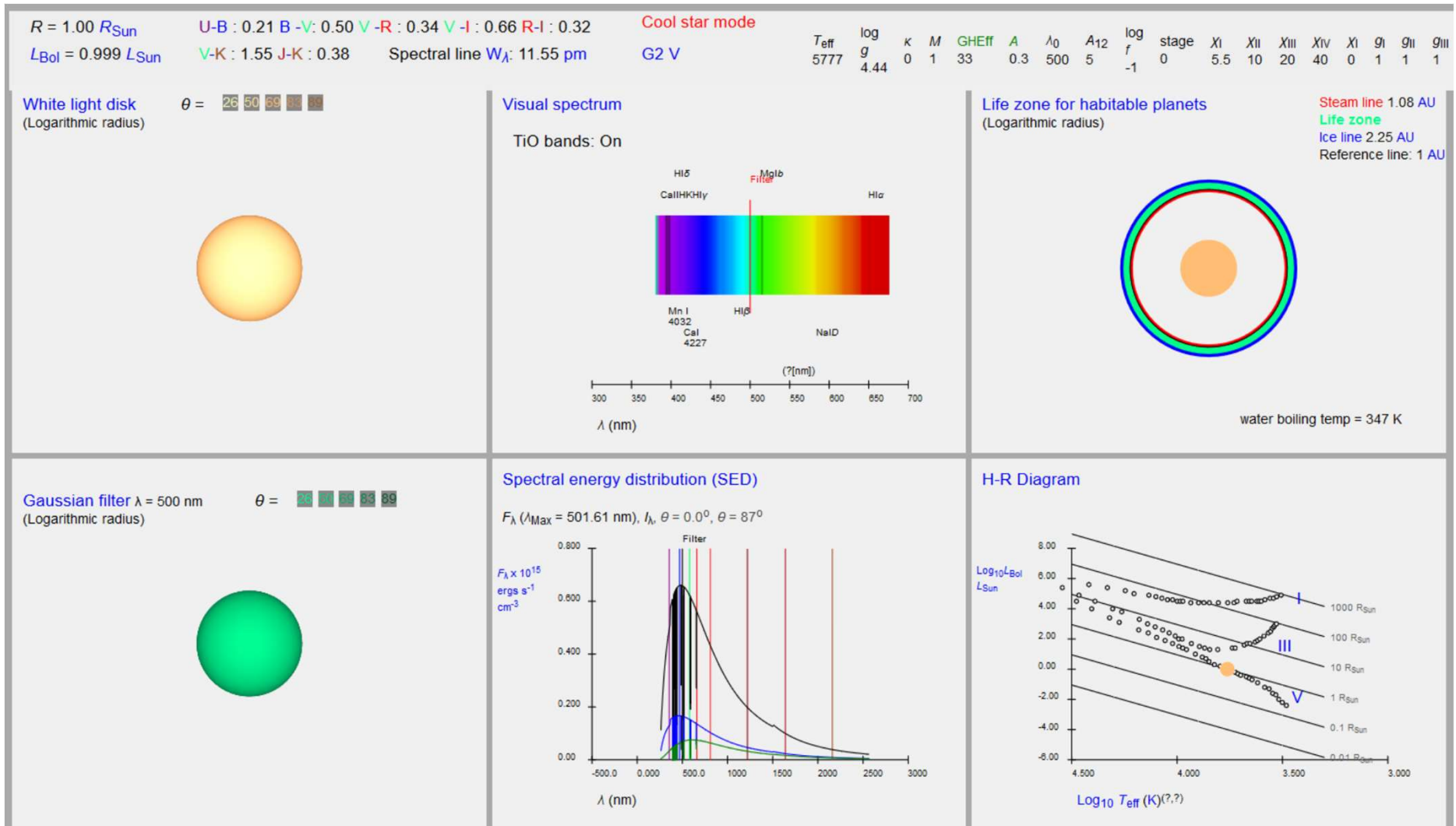
ChromaStar: A star and exo-planet in the classroom



www.ap.smu.ca/OpenStars

Ian Short

Model star & exo-planet life zone



JavaScript source code in browser

The image shows a web browser window displaying the ChromaStar application. The browser's address bar shows the URL `www.ap.smu.ca/~ishort/OpenStars/ChromaStar/ChromaStar.html`. The page title is "ChromaStar (formerly 'GrayStar')".

The application interface includes a "MODEL" button and an "Input:" section. Under "Input:", there are two sub-sections: "Show/Hide stellar" and "Show/Hide habitable zone".

The "Stellar parameters" section contains four sliders and four input fields:

- Effective temperature, T_{eff} (3400 - 50000) K: 4500
- Log₁₀ surface gravity, log(g) (0.0 - 5.5 cm s⁻² = dynes g⁻¹): 1
- Stellar mass (0.1 - 20.0 M_{Sun}): 0.5
- Metal content (log₁₀ 0.001 - 10.0 x solar): 0
- KFudge log₁₀ mass extinction (-2.0 - 2.0 log cm² g⁻¹): 0.0
- [He/Fe] (-1 - 1): 0.0
- [C/O] (-2 - 2): 0.0
- [α/Fe] (-0.5 - 0.5): 0.0

The "Habitable Planet Zone parameters" section is currently hidden.

The browser's developer tools are open, showing the "Sources" panel. The file `ChromaStarAtmos.js` is selected, and the following JavaScript code is visible:

```
80 //Log_10 Rosseland optical depth scale
81 // CAUTION: Here tau[1][] is log_10!
82 var tauScale = function(numDeps, log10MinDepth,
83
84 //Log_10 Rosseland optical depth scale
85 //Java: double tauRos[][] = new double[2][numDeps];
86 //var tauRos = new double[2][numDeps];
87     var dummy0 = [];
88     var dummy1 = [];
89     dummy0.length = numDeps;
90     dummy1.length = numDeps;
91     var tauRos = [
92         dummy0,
93         dummy1
94     ];
95     // Construct the Log Rosseland optical depth
96     // Trv equal spacing in log depth
```

The status bar at the bottom of the developer tools indicates "Line 93, Column 15".

showHide stellar

Stellar parameters

Effective temperature, T_{eff} (3400 - 50000) K:

Log₁₀ surface gravity, log(g) (0.0 - 5.5 cm s⁻² = dynes g⁻¹):

Stellar mass (0.1 - 20.0 M_{Sun}):

Metal content (log₁₀ 0.001 - 10.0 x solar):

K_{ext} log₁₀ mass extinction (-2.0 - 2.0 log cm² g⁻¹):

[He/Fe] (-1 - 1):

[C/O] (-2 - 2):

[α /Fe] (-0.5 - 0.5):

showHide habitable zone

showHide spectral line

showHide samples

showHide performance/realism

MODEL

Output:

Narrow band Gaussian filter
 λ (270 - 2550 nm) σ (0.01 - 10 nm)

Plots:
 Atmosphere Chem Eq (if Atmos plots ON) Radiation field 2-level atom: spectral line

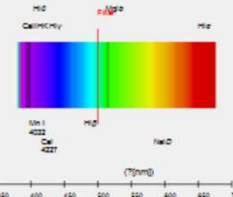
Detailed print-out (below graphs):
 None Atmospheric structure Flux spectral energy distribution (SED) Specific intensity distribution High resolution spectral line profile Limb darkening coeffs Che

$R = 1.00 R_{\text{Sun}}$ $U-B: 0.21$ $B-V: 0.50$ $V-R: 0.34$ $V-I: 0.66$ $R-I: 0.32$ **Cool star mode** T_{eff} $\log g$ κ M $GHEff$ A A_0 A_{12} $\log f$ stage X_I X_{II} X_{III} X_{IV} X_I g_I g_{II}
 $L_{\text{Bol}} = 0.999 L_{\text{Sun}}$ $V-K: 1.55$ $J-K: 0.38$ Spectral line λ : 11.55 μm $G2 V$ 5777 4.44 0 1 33 0.3 500 5 -1 0 5.5 10 20 40 0 1 1 1 1

White light disk (Logarithmic radius) $\theta =$



Visual spectrum
TiO bands: On



λ (nm)

Life zone for habitable planets (Logarithmic radius)

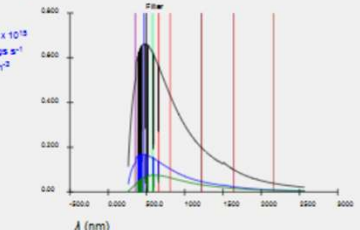


Steam line 1.08 AU
Life zone
Ice line 2.25 AU
Reference line: 1 AU
water boiling temp = 347 K

Gaussian filter $\lambda = 500$ nm $\theta =$



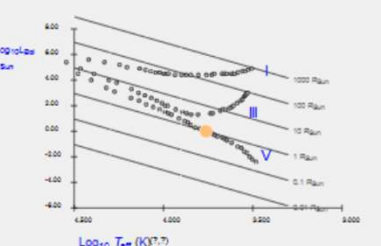
Spectral energy distribution (SED)
 F_{λ} ($\lambda_{\text{max}} = 501.81$ nm), i_{λ} , $\theta = 0.0^\circ$, $\theta = 87^\circ$



$F_{\lambda} \times 10^{13}$ ergs s⁻¹ cm⁻²

λ (nm)

H-R Diagram



$\log_{10} L_{\text{star}} / L_{\text{Sun}}$

$\log_{10} T_{\text{eff}} (K)^{1.7}$

Basic stellar inputs

Show/Hide stellar

Stellar parameters

Effective temperature, T_{eff}
(3400 - 50000) K

5777

Log₁₀ surface gravity, log(g)
(0.0 - 5.5 cm s⁻² = dynes g⁻¹)

4.44

Stellar mass
(0.1 - 20.0 M_{Sun})

1

κ_{Fudge} log₁₀ mass extinction (-2.0 - 2.0 log cm² g⁻¹)

0

[He/Fe] (-1 - 1)

0

[C/O] (-2 - 2)

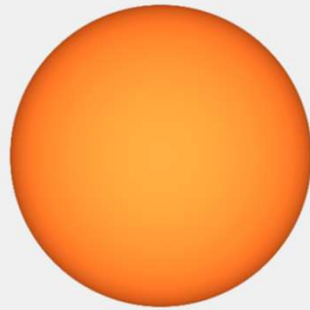
0

Show/Hide habitable zone

T_{eff} – Colour relation

White light disk
(Logarithmic radius)

$\theta =$ 26 50 69 83 89



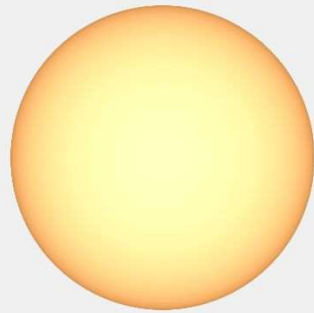
Effective temperature, T_{eff}
(3400 - 50000) K



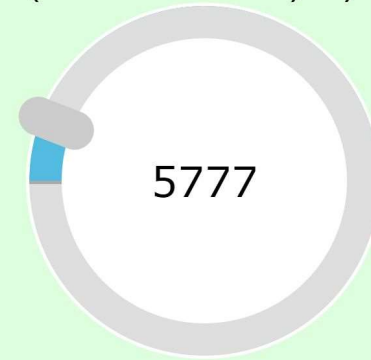
T_{eff} – Colour relation

White light disk
(Logarithmic radius)

$\theta =$ 26 50 69 83 89



Effective temperature, T_{eff}
(3400 - 50000) K



T_{eff} – Colour relation

White light disk
(Logarithmic radius)

$\theta =$ 26 50 69 83 89



Effective temperature, T_{eff}
(3400 - 50000) K

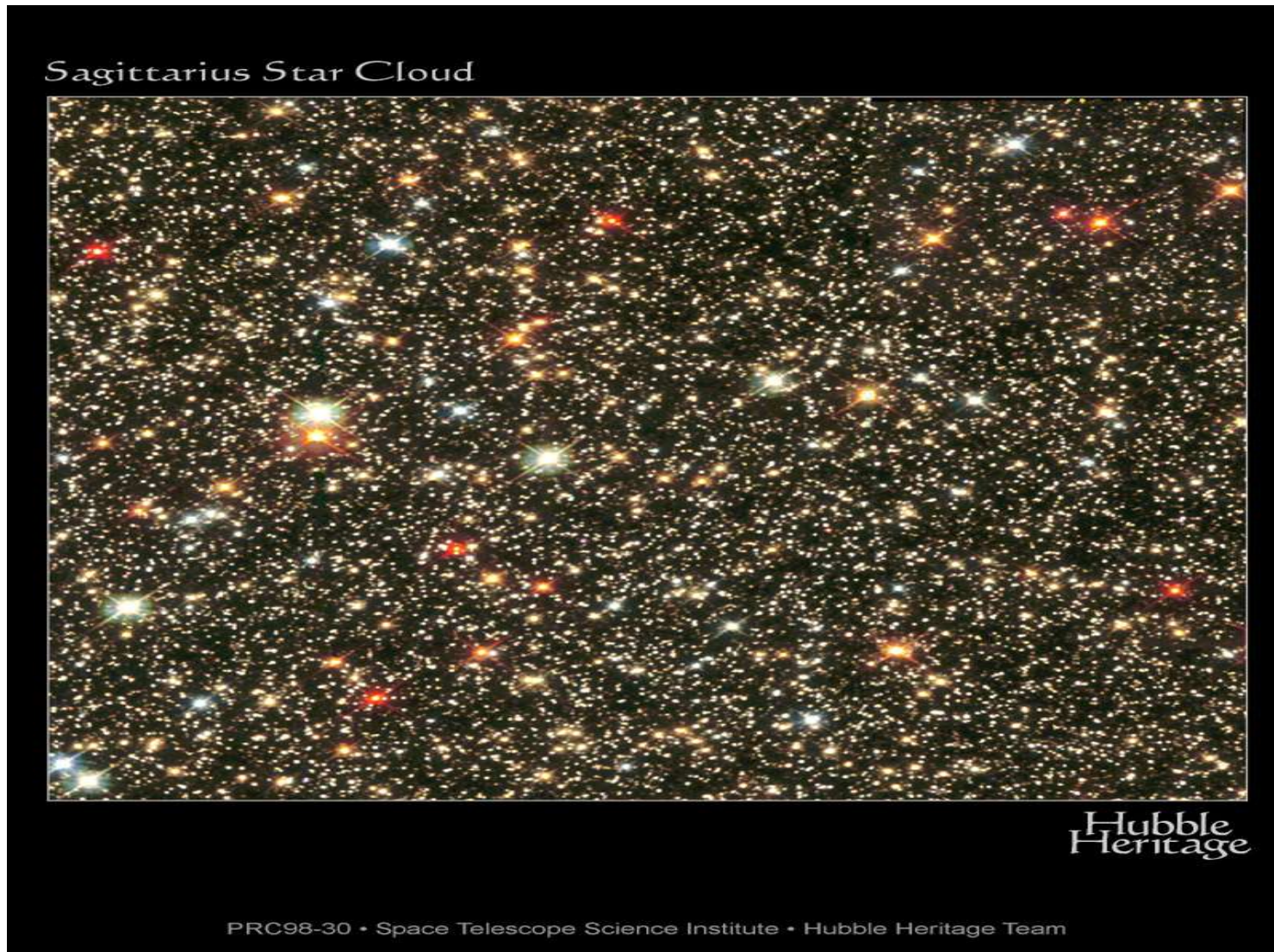


Basic activity:

T_{eff} estimation by colour matching

Credit:

STScI Hubble Heritage Gallery



T_{eff} – Spectral class relation

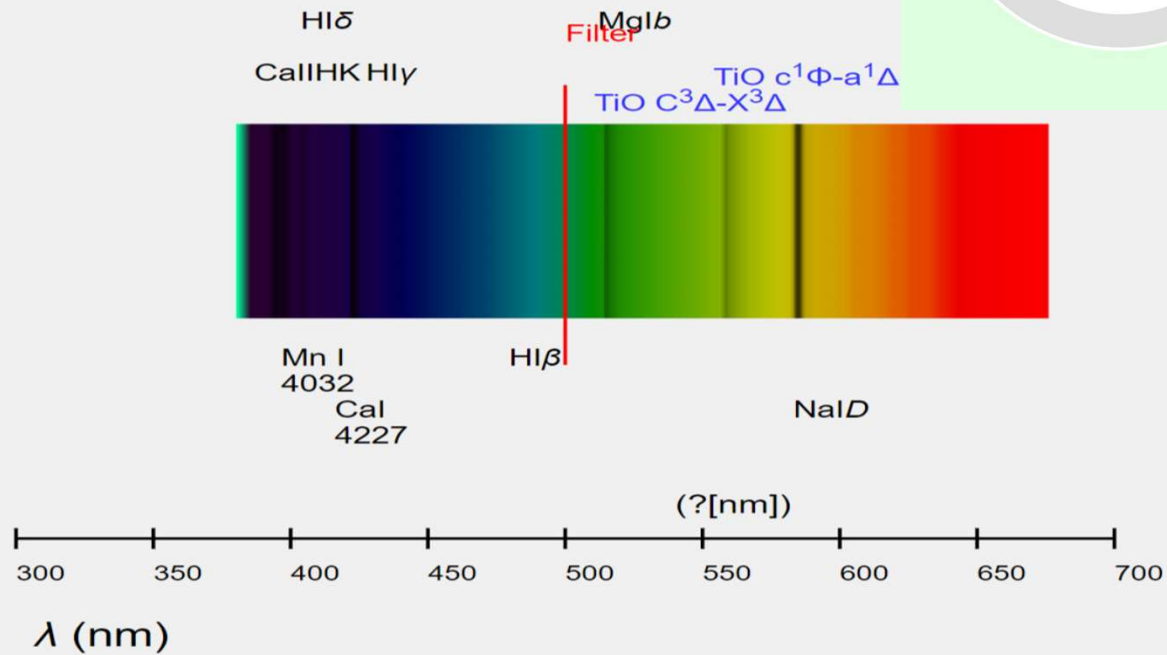
M dwarf

Effective temperature, T_{eff}
(3400 - 50000) K



Visual spectrum

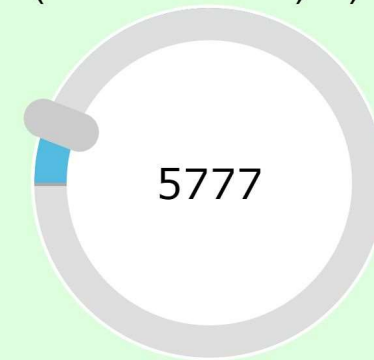
TiO bands: On



T_{eff} – Spectral class relation

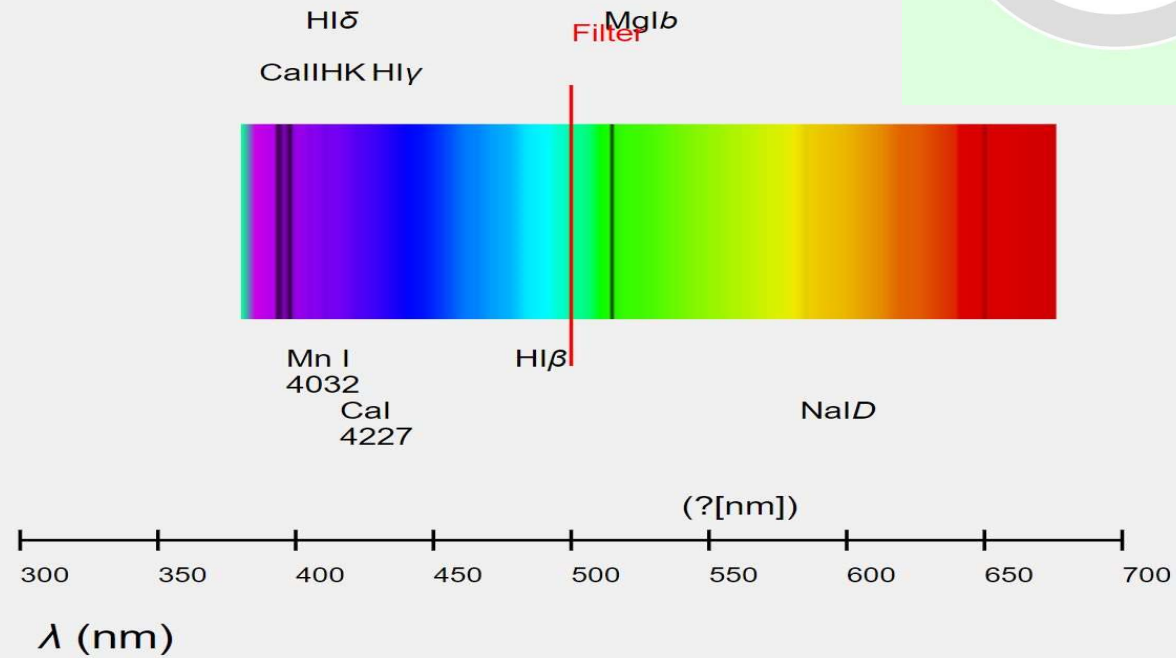
Sun

Effective temperature, T_{eff}
(3400 - 50000) K



Visual spectrum

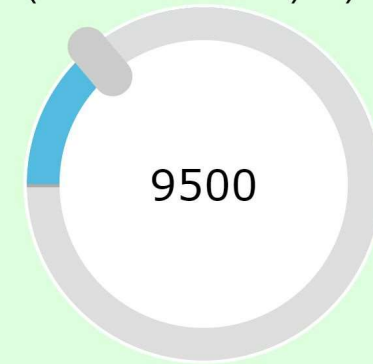
TiO bands: On



T_{eff} – Spectral class relation

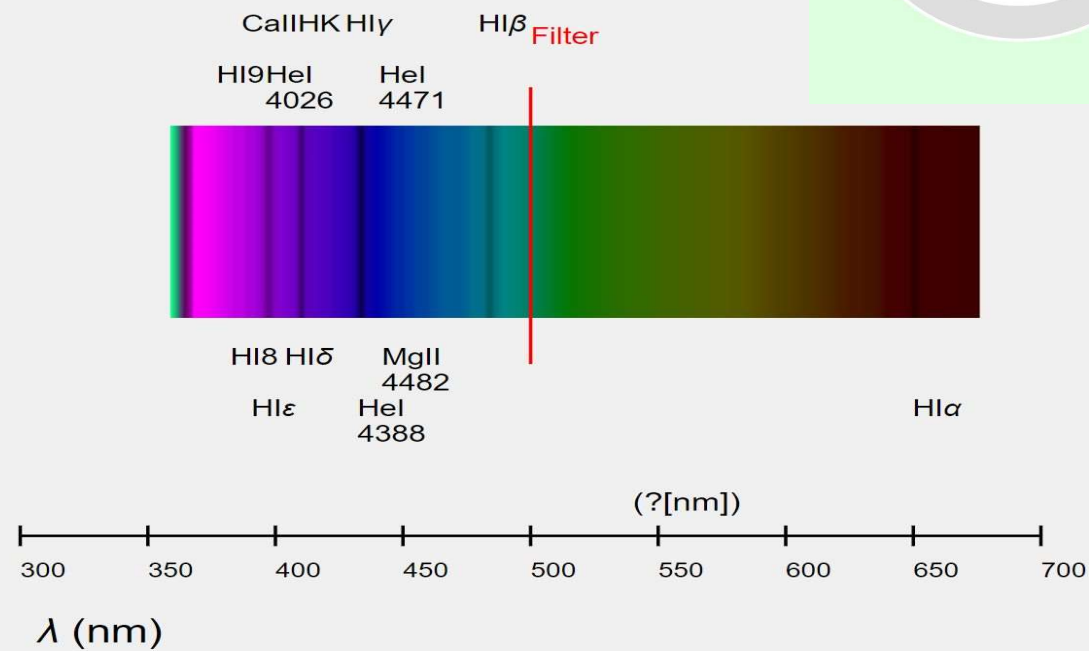
A0 star (Vega)

Effective temperature, T_{eff}
(3400 - 50000) K



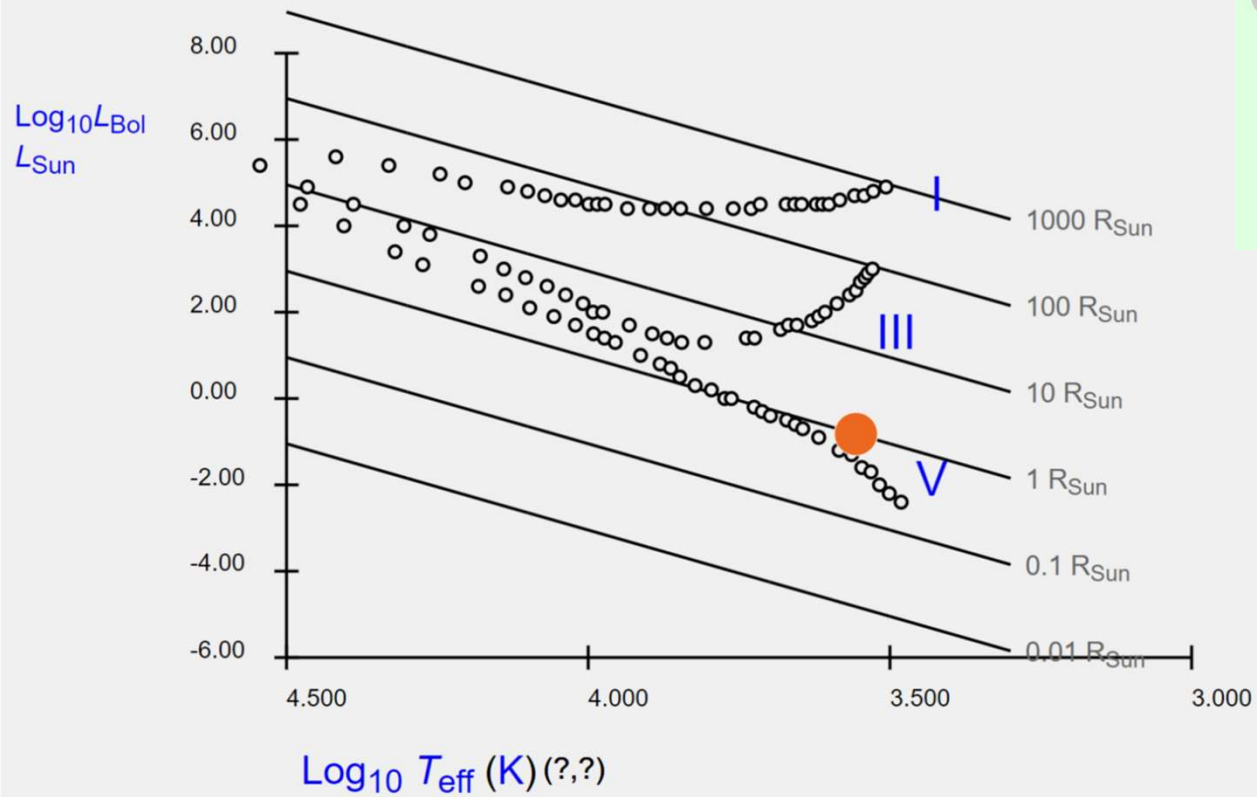
Visual spectrum

TiO bands: On



Comparison to real stars: M dwarf

H-R Diagram

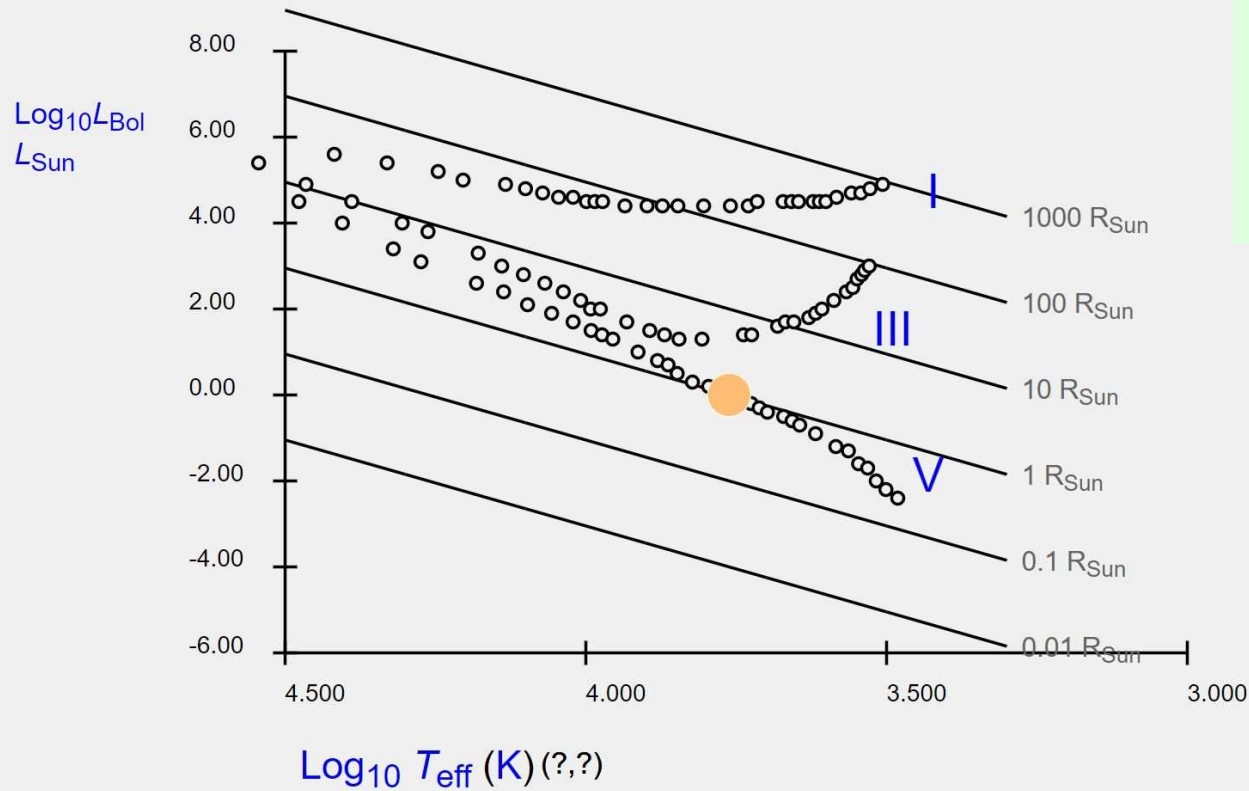


Effective temperature, T_{eff}
(3400 - 50000) K

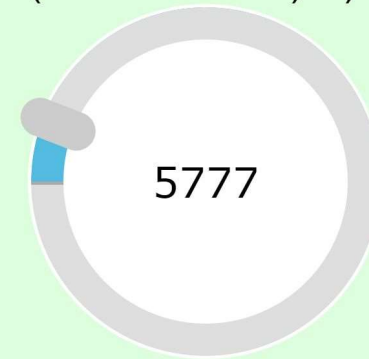


Comparison to real stars: Sun

H-R Diagram



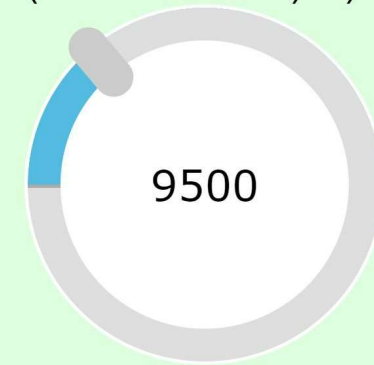
Effective temperature, T_{eff}
(3400 - 50000) K



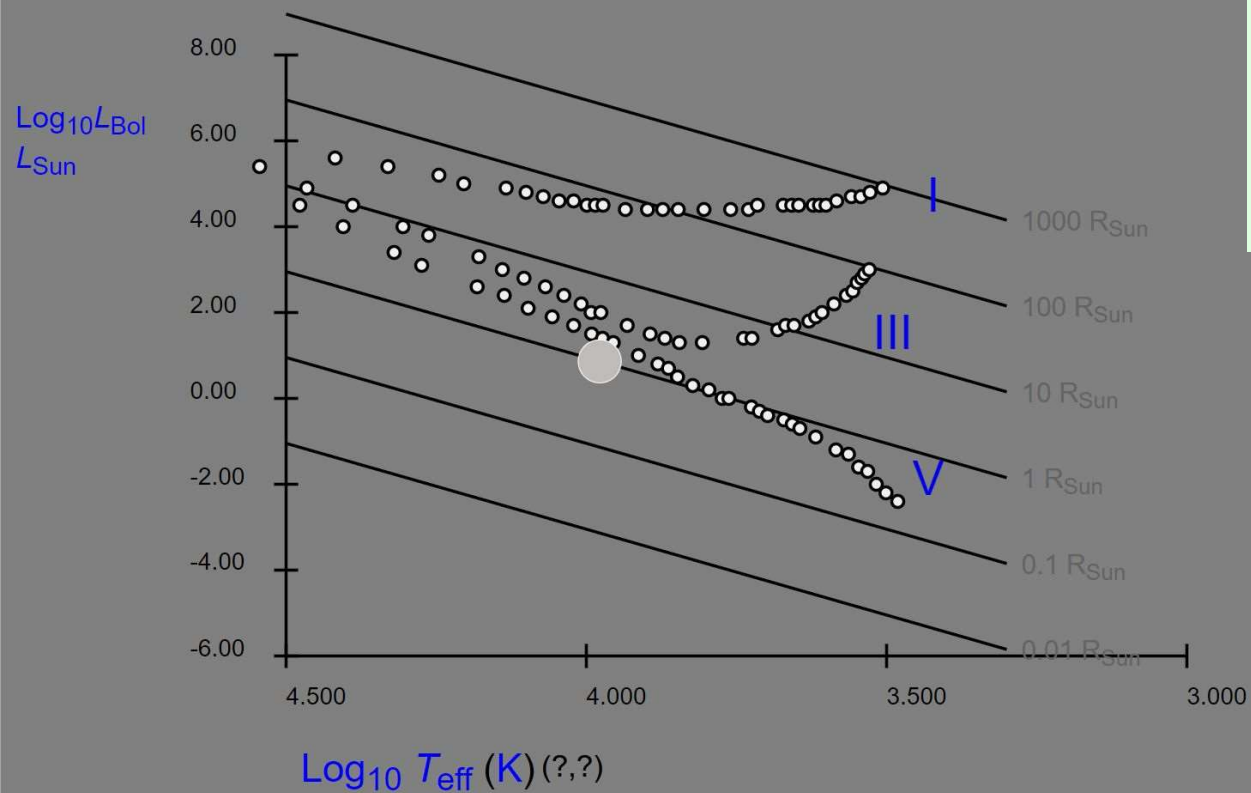
Comparison to real stars

A0 star (Vega)

Effective temperature, T_{eff}
(3400 - 50000) K

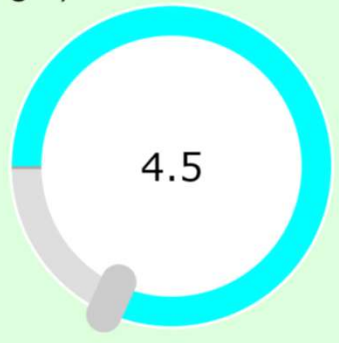


H-R Diagram

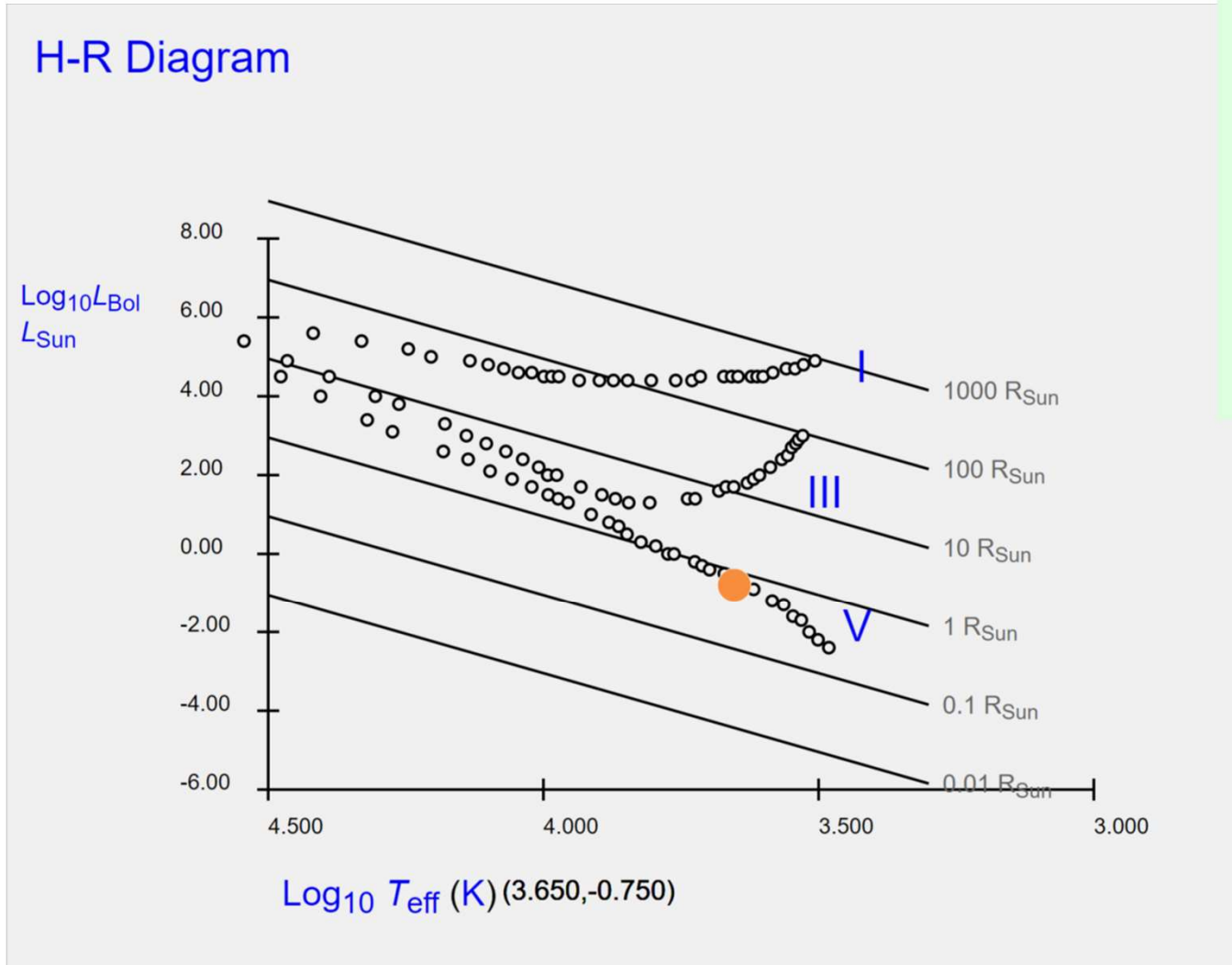


log g – L relation: Dwarf

Log₁₀ surface gravity,
log(g)
(0.0 - 5.5 cm s⁻² = dynes
g⁻¹)



4.5

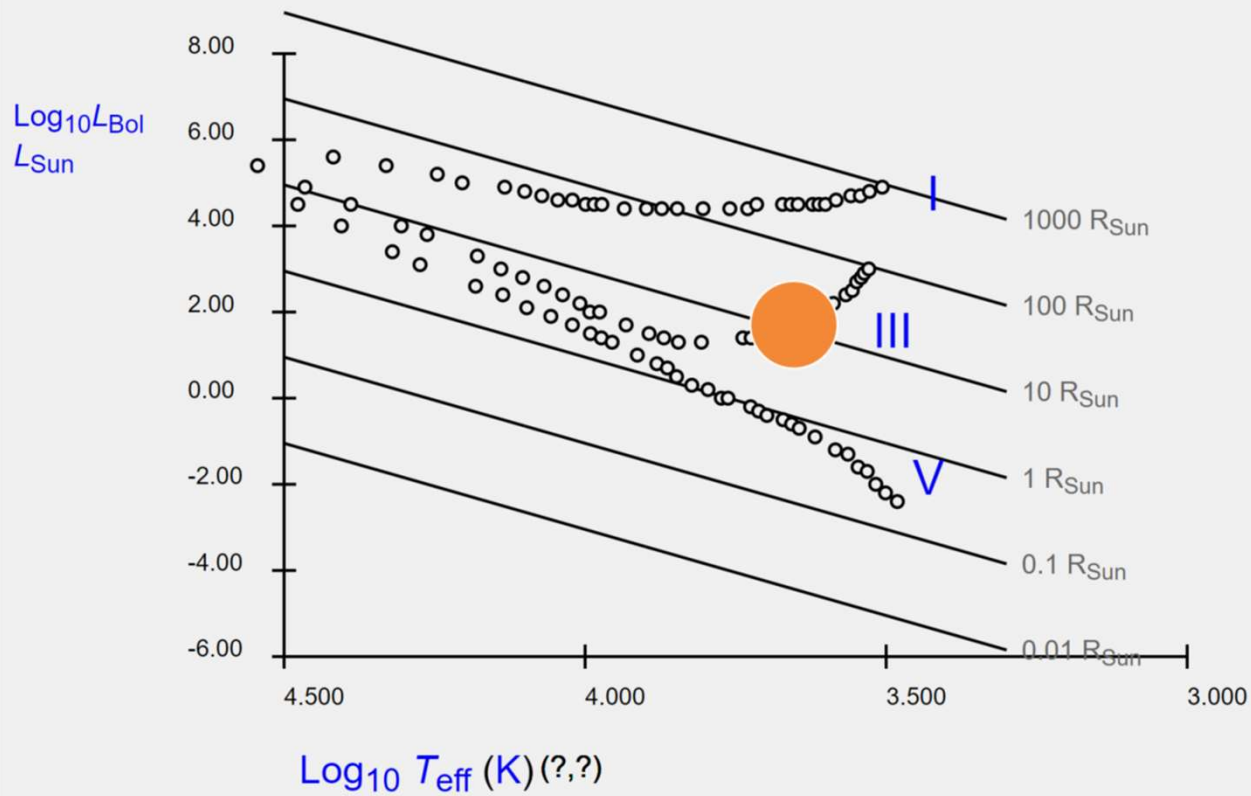


log g – L relation: Giant

Log₁₀ surface gravity, log(g)
(0.0 - 5.5 cm s⁻² = dynes g⁻¹)

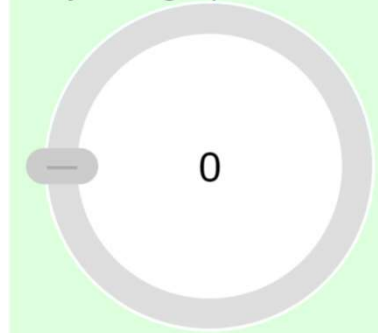


H-R Diagram

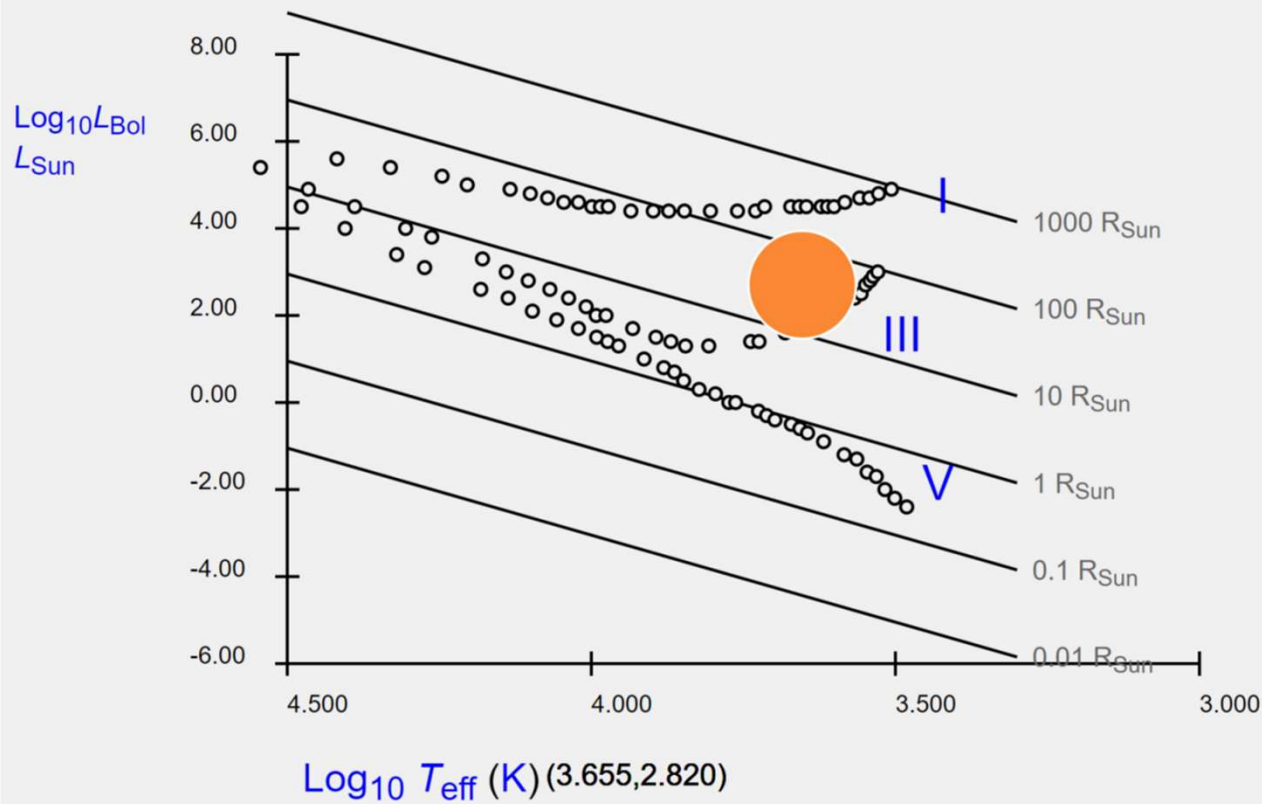


log g – L relation: Bright giant

Log₁₀ surface gravity, log(g)
(0.0 - 5.5 cm s⁻² = dynes g⁻¹)



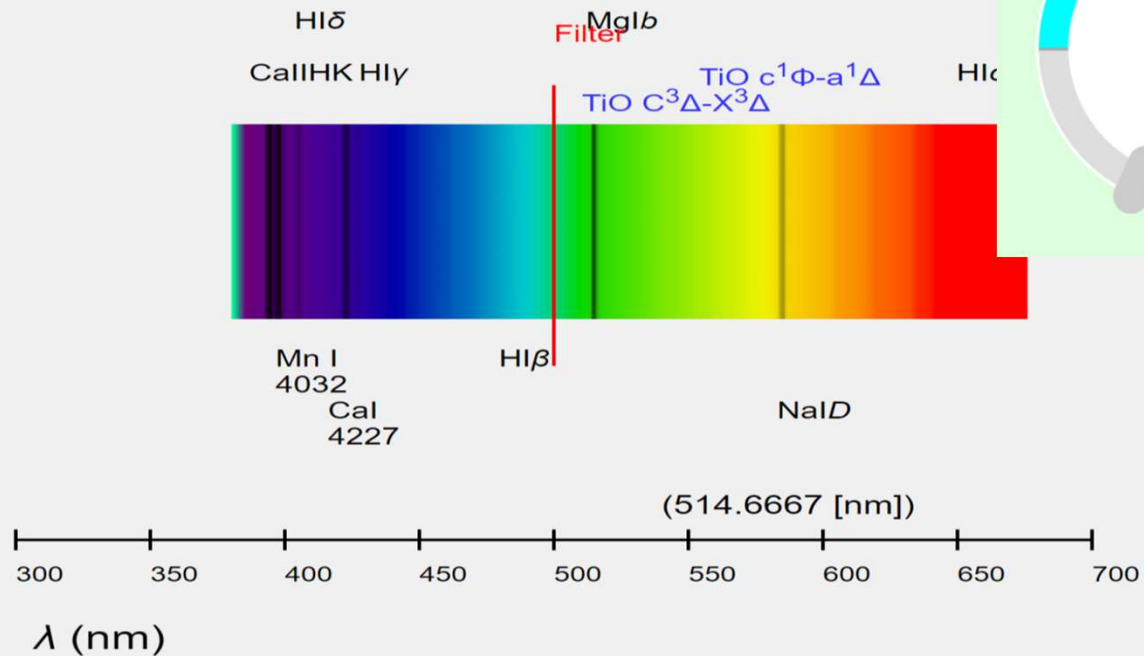
H-R Diagram



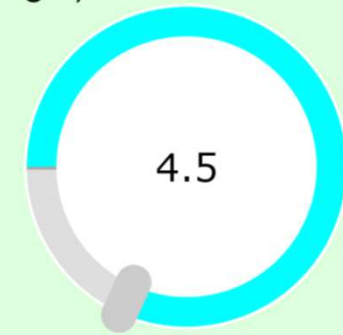
Luminosity class: V Dwarf

Visual spectrum

TiO bands: On



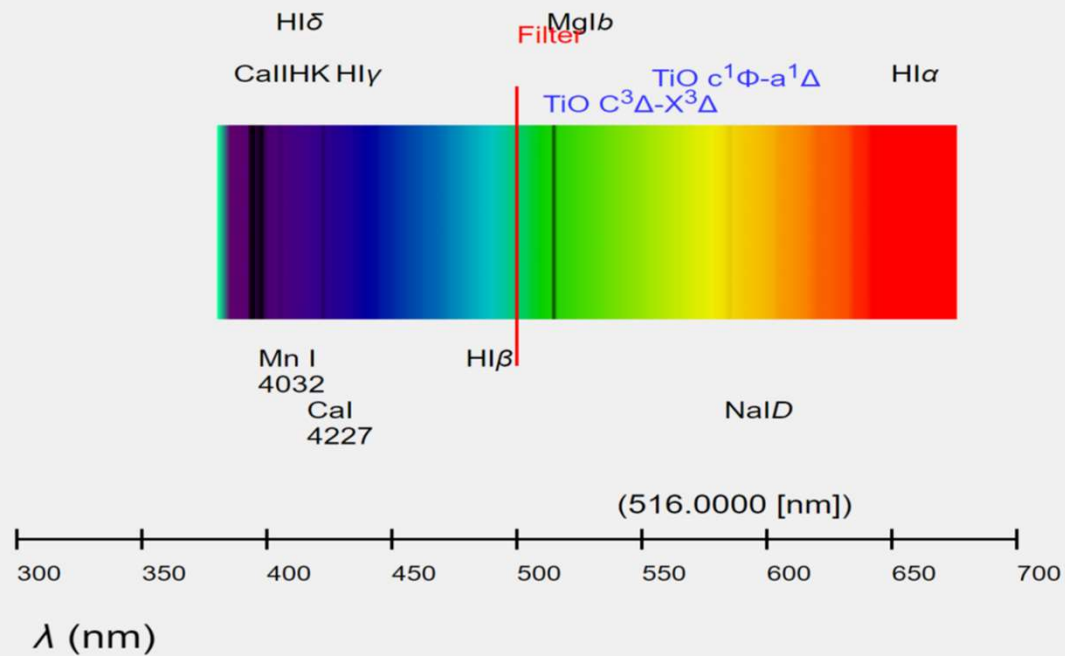
Log₁₀ surface gravity,
log(*g*)
(0.0 - 5.5 cm s⁻² = dynes
g⁻¹)



Luminosity class: III Giant

Visual spectrum

TiO bands: On



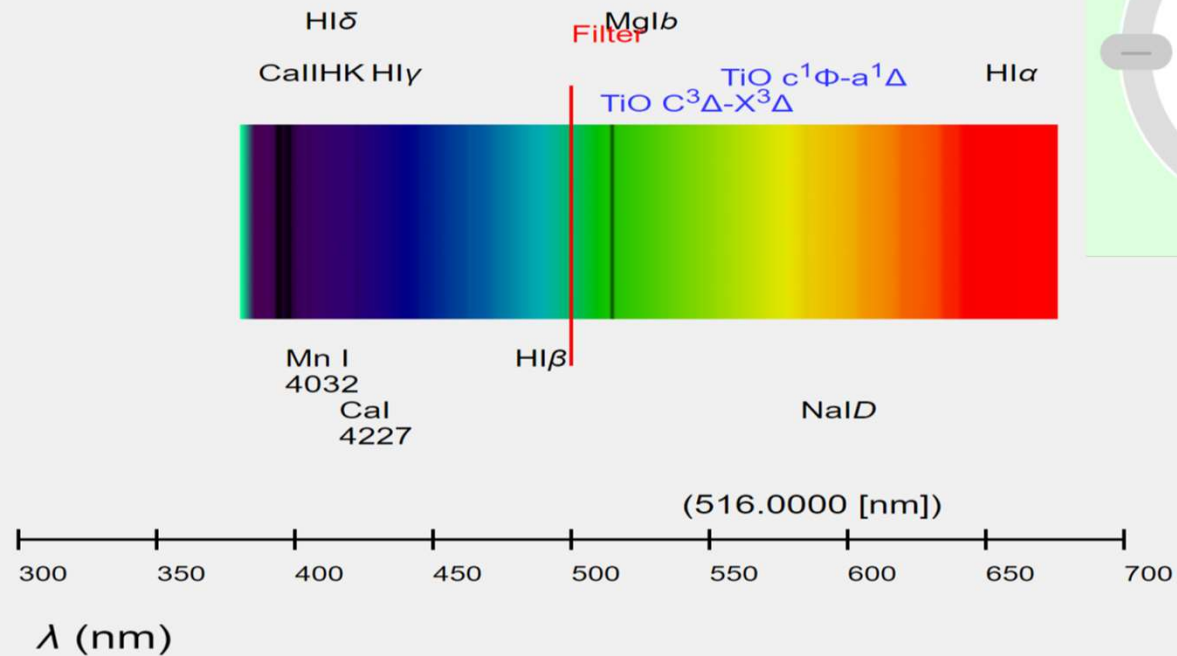
Log₁₀ surface gravity, log(*g*)
(0.0 - 5.5 cm s⁻² = dynes g⁻¹)



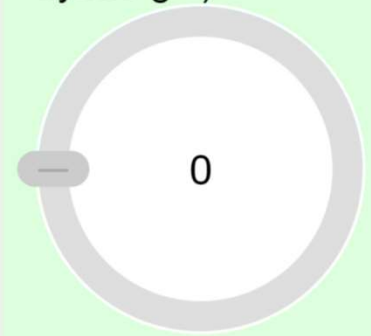
Luminosity class: II Bright giant

Visual spectrum

TiO bands: On



Log₁₀ surface gravity, log(*g*)
(0.0 - 5.5 cm s⁻² = dynes g⁻¹)



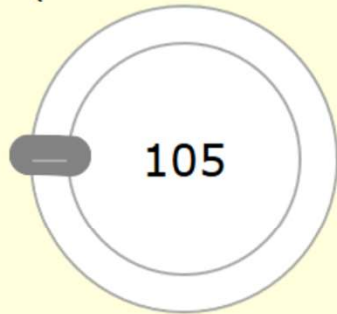
Planetary inputs

Show/Hide stellar

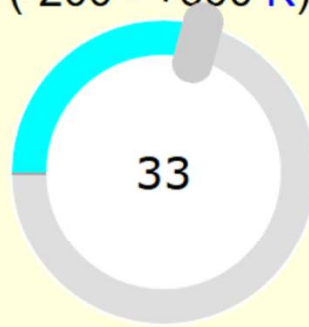
Show/Hide
habitable zone

Habitable Planet Zone parameters

Surf pressure
(0.6 - 22000 kPa)



Greenhouse effect, ΔT
(-200 - +600 K)



Albedo (0.0 - 0.95)



Organic solvent

Water

Methane

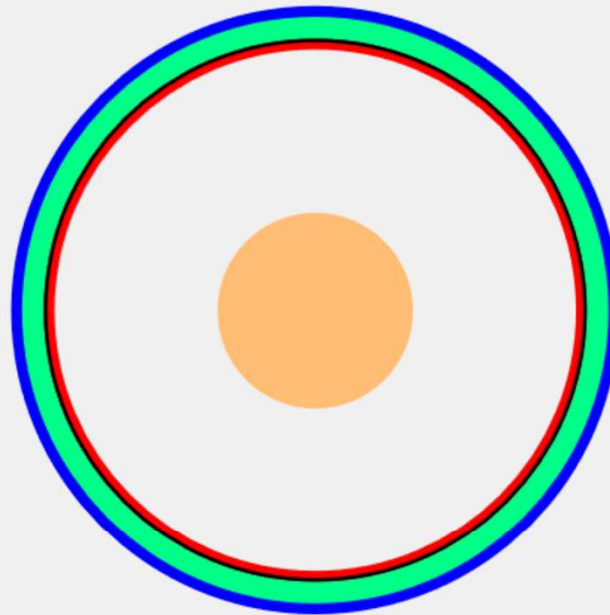
Ammonia

Carbon dioxide

Sun - Earth

Life zone for habitable planets
(Logarithmic radius)

Steam line 1.08 AU
Life zone
Ice line 2.25 AU
Reference line: 1 AU



water boiling temp = 347 K

Eg. Sun – Titan: Inputs

Show/Hide stellar

Show/Hide habitable zone

Habitable Planet Zone parameters

Surf pressure (0.6 - 22000 kPa)

Greenhouse effect, ΔT (-200 - +600 K)

Albedo (0.0 - 0.95)

150

-11

0.22

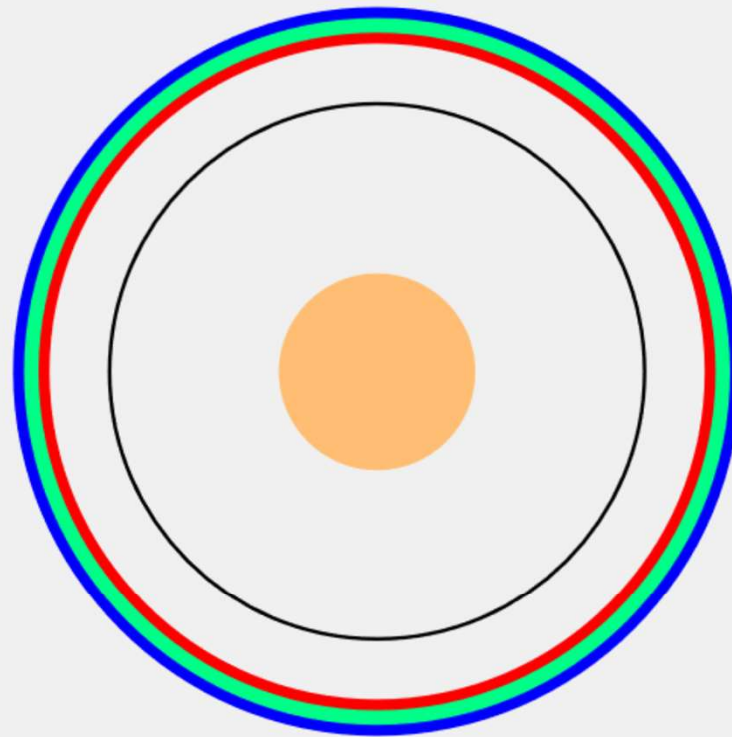
Organic solvent

- Water
- Methane
- Ammonia
- Carbon dioxide

Eg. Titan – Output methane life zone

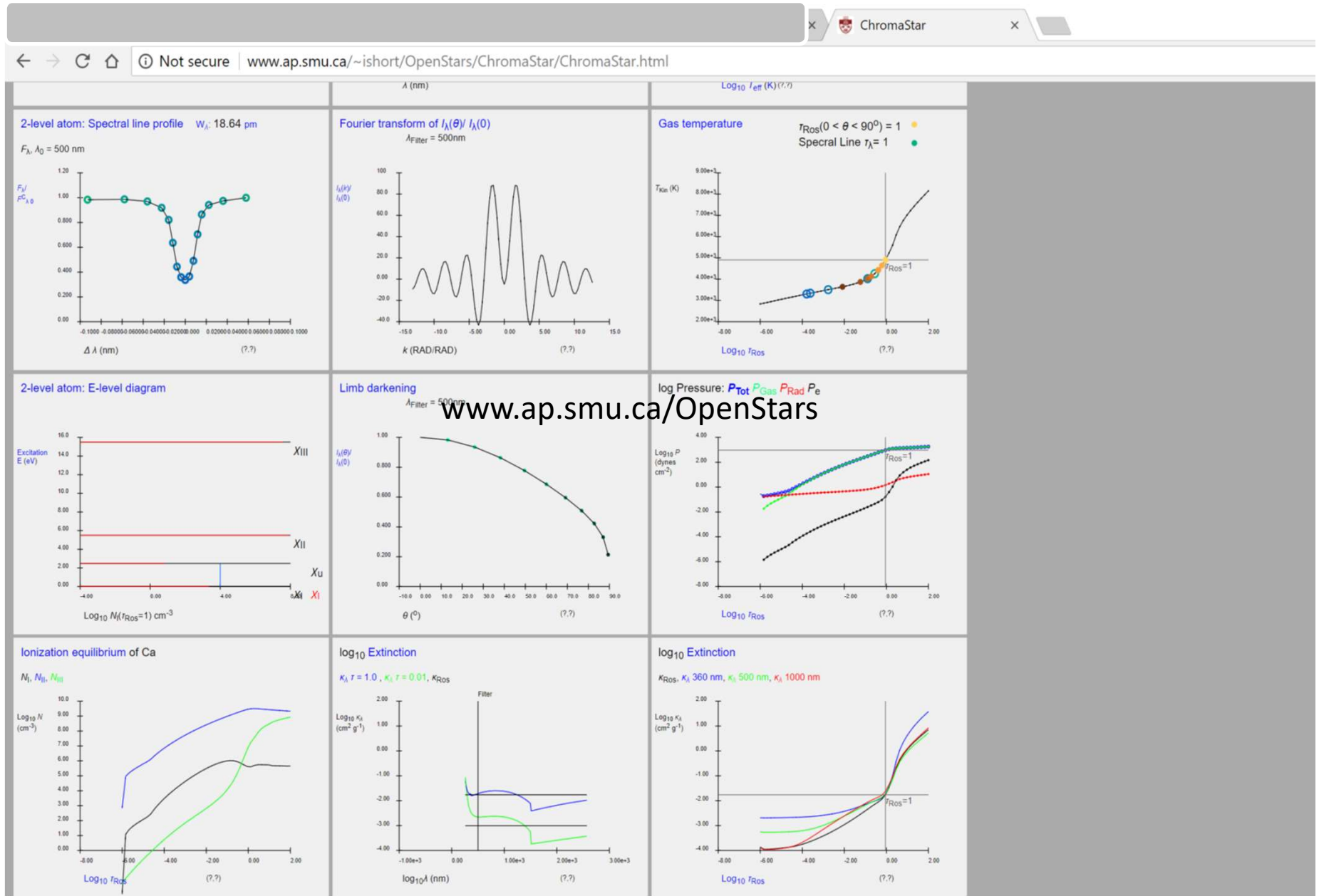
Life zone for habitable planets
(Logarithmic radius)

Steam line 8.41 AU
Life zone
Ice line 13.3 AU
Reference line: 1 AU



methane boiling temp = 128 K

Optional advanced output



www.ap.smu.ca/OpenStars